APPENDIX F

Water Quality Improvements from Similar Construction Control Programs

To assess potential water quality improvements that could be associated with Phase I construction controls, EPA sought to identify jurisdictions that (1) experience a high rate of construction activity and (2) are located within a watershed that has been monitored for changes in water quality indicators. The water quality data used for this analysis came from the U.S. Geological Survey's National Stream Water Quality Monitoring Networks (WQN). The construction data came from the U.S. Census Bureau's Building Permit Database.

The monitoring data currently available from the WQN cover the period from 1973 until approximately 1994. The construction permit data from the Census Bureau are for the period between 1980 and 1994. On the other hand, Phase I construction controls were not put in place until October 1992. Consequently, there were insufficient WQN data for a meaningful comparison between before and after conditions. Therefore, it was necessary to look for high-growth areas that had put erosion and sediment control provisions into place prior to Phase I and that had requirements that were at least as rigorous as those required under Phase I. These areas offer a surrogate means for assessing the potential for improvements as a result of Phase I construction controls.

Approach

Under the Coastal Zone Management Act of 1972, coastal states were required to develop a coastal zone management program to protect coastal resources from the impact of human activity. As part of this program, many states implemented erosion and sediment control provisions in their coastal areas. EPA conducted a screening analysis to assess each coastal state for the number of "high growth counties" which fell under the jurisdiction of their coastal zone management program. High growth counties were defined as those counties that experienced a minimum of 600 estimated construction starts during the year 1994.

As a result of the screening analysis, the state of Florida was chosen to be profiled. In 1994, Florida had 24 high growth counties as defined in this analysis. There are also numerous USGS monitoring stations located within the state. In addition in September 1981, the State of Florida, as a result of "the unique biogeographic conditions found in Florida," included the entire state in the coastal zone.[4] Furthermore, in 1986 Florida adopted a comprehensive beach management program under which all coastal counties were required to implement erosion and sediment control provisions for construction activities. This provided a suitable before and after time period for the analysis. The period from 1980 to 1986 represents the pre-erosion and sediment control conditions and the period of 1987 until 1994 represents the post-erosion and sediment control conditions.

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[4]Florida Department of Environmental Protection. *Intergovernmental Programs Manual*, www.dep.state.fl.us/legis/igovprg/manual.htm. Accessed 1/8/2000.

The WQN data provide daily flow sample values, as well as total suspended sediment (TSS) samples taken periodically throughout the year. However, the completeness of the data varies between stations and from year to year. Therefore, monitoring stations with gaps of a year or more in their data set were not considered for the analysis. A total of 11 Florida monitoring stations were eventually considered for the study. The WQN monitoring data from these stations were used to derive annual sediment load estimates for their corresponding watersheds.

For there to be evidence of water quality improvements that could potentially be attributable to the implementation of erosion and sediment controls, sediment from development within the watershed must be a significant source of sediment entering the waterway. However, two issues may complicate this relationship:

(1) There are many potential sources of sediment to the watershed other than construction sites. Agricultural activities can be a major source of sedimentation in waterways. In heavily urbanized areas, large pulses of storm water runoff can cause in-stream erosion, which can affect sediment levels within the waterway.

(2) Many watersheds are down stream from other watersheds. TSS loadings within the waterway are derived from sediment entering the waterway from its own watershed and also from upstream reaches.

These factors can obscure the potential impact of construction site erosion on sediment loads to waterways. However, since an effort was made to find monitoring stations in high-growth areas, the effects of the first issue might have been attenuated.

Sediment loads within a watershed are also highly dependent upon rainfall events. Fluctuations in rainfall and storm intensity both are major contributors to annual sediment loadings. To lessen the influence of fluctuations in precipitation, average annual rainfall data for the entire state of Florida was used to normalize the sediment load data.

To find evidence of reduction in sediment loads that can potentially be attributed to the implementation of erosion and sediment control provisions, annual sediment loads from each watershed had to be compared to annual construction levels for the counties that correspond to the watershed. Watersheds were grouped with counties based upon the watershed's USGS hydrologic unit code (HUC). For each watershed the construction permit data for the counties that are completely or partially located within the watershed were summed. Table F-1 shows a list of the 16 high-growth counties considered, and Table F-2 shows how they correspond to one or more of the watersheds.

Since the variability of weather in many cases can obscure potential underlying year to year trends in sediment loads, long time periods need to be used to find trends in sediment loadings. There was insufficient long term data to produce actual year to year trends in sediment loads for each watershed. Instead, the mean annual sediment loading value for the period 1980–1986 was compared to the 1987–1994 mean for each watershed. The same comparison could then be made for the average annual number of construction permits for each watershed's corresponding counties.

Results

Table F-3 shows the results of the comparisons. The relative increase or decrease in sediment loads is compared to the relative increase or decrease in construction starts. To suggest that erosion and sediment controls reduce sediment loads, the average annual sediment loads would need to either decrease or at least increase by a lower percentage when average annual construction levels increase. Conversely, if no relationship exists and the statistics are independent, construction decreases would result in corresponding decreases in sediment loading rates. The plus and minus symbols in the last column of Table F-3 shows how often this did or did not occur. As shown it occurred for only 5 out of the 11 watersheds. When both the sediment loads and construction permits are summed over the watersheds the table shows that in aggregate both total sediment loadings and construction decreased. Sediment loading decreased by 31 percent while construction starts essentially remained the same.

Table F-1. Total Building Starts for Florida High Growth Counties Considered for the Analysis

County Code*	County Name	Total Building Starts by Year														
		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	Alachua	3,757	3,754	3,811	4,490	4,018	4,027	4,331	3,651	3,669	3,629	3,566	3,547	3,727	4,003	3,556
9	Brevard	11,605	12,091	11,869	12,912	15,136	16,619	13,226	10,576	10,549	10,644	9,908	8,480	9,810	9,868	9,677
21	Collier	4,357	5,666	5,120	6,153	3,445	4,263	3,112	3,998	4,329	4,424	5,730	4,921	6,155	5,915	4,374
31	Duval	5,660	5,340	6,163	8,662	8,567	9,383	9,709	11,459	10,693	9,652	9,267	8,325	9,224	9,659	10,573
33	Escambia	n.a.	3,713	4,669	6,342	6,518	5,803	5,756	3,939	3,782	4,104	3,487	3,239	3,967	4,033	10,573
55	Highlands	3,047	3,042	2,787	3,088	3,447	3,736	3,864	3,367	3,153	3,264	2,663	2,699	3,119	3,192	2,984
57	Hillsborough	16,242	16,842	16,418	17,873	17,977	17,776	17,285	15,370	14,683	14,470	13,122	12,966	13,470	14,042	14,449
69	Lake	3,504	3,836	3,714	5,250	4,411	4,691	6,080	7,447	7,690	7,885	6,631	6,430	7,096	7,791	6,599
71	Lee	11,407	10,633	12,408	17,957	18,520	18,538	13,313	17,861	15,275	13,828	12,685	10,690	11,139	12,970	12,242
83	Marion	4,183	4,313	4,280	5,636	5,995	6,855	7,634	10,428	4,765	6,387	4,339	6,375	7,021	7,205	7,623
91	Okaloosa	1,384	1,308	2,710	3,278	3,405	3,388	3,227	3,387	3,003	2,807	2,399	2,994	3,321	3,565	3,825
95	Orange	16,156	15,677	14,879	19,936	21,491	21,777	18,058	22,396	22,278	22,415	19,961	18,728	20,244	18,790	16,779
97	Osceola	6,545	6,404	5,238	7,707	5,776	5,114	4,609	5,481	6,173	4,660	5,262	4,521	4,270	4,105	3,837
105	Polk	10,706	10,578	9,292	12,222	11,800	12,518	13,487	13,234	10,382	9,112	8,003	8,522	10,491	11,809	11,150
117	Seminole	6,904	6,073	6,282	9,456	9,779	10,192	8,301	8,626	9,645	8,049	8,163	5,934	5,822	6,644	5,570
127	Volusia	10,013	8,950	9,358	11,554	12,620	13,319	13,430	6,670	13,241	12,149	9,544	8,133	8,025	7,778	7,955

* County Codes used by the U.S. Census Bureau.

Table F-2. Florida Watersheds, Their Corresponding Counties and Total Building Starts

Watershed HUCs	Corresponding County Codes	Total Building Starts by Year															Annual Average		Change in Average
		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	80-86	87–94	
3080101	**9, 69, 83, 95, 97, 117, 127**	58,910	57,344	55,620	72,451	75,208	78,567	71,338	71,624	74,341	72,189	63,808	58,601	62,288	62,181	58,040	67,063	65,384	1,679
3080201	**31, 127**	15,673	14,290	15,521	20,216	21,187	22,702	23,139	18,129	23,934	21,801	18,811	16,458	17,249	17,437	18,528	18,961	19,043	-82
3090101	**55, 69, 95, 97, 105**	39,958	39,537	35,910	48,203	46,925	47,836	46,098	51,925	49,676	47,336	42,520	40,900	45,220	45,687	41,349	43,495	45,577	-2,081
3090103	**55**	3,047	3,042	2,787	3,088	3,447	3,736	3,864	3,367	3,153	3,264	2,663	2,699	3,119	3,192	2,984	3,287	3,055	232
3090205	**21, 71**	15,764	16,299	17,528	24,110	21,965	22,801	16,425	21,859	19,604	18,252	18,415	15,611	17,294	18,885	16,616	19,270	18,317	953
3100101	**55, 57, 105**	29,995	30,462	28,497	33,183	33,224	34,030	34,636	31,971	28,218	26,846	23,788	24,187	27,080	29,043	28,583	32,004	27,465	4,539
3100204	**57, 105**	26,948	27,420	25,710	30,095	29,777	30,294	30,772	28,604	25,065	23,582	21,125	21,488	23,961	25,851	25,599	28,717	24,409	4,307
3110206	**1**	3,757	3,754	3,811	4,490	4,018	4,027	4,331	3,651	3,669	3,629	3,566	3,547	3,727	4,003	3,556	4,027	3,669	358
3140103	**91**	1,384	1,308	2,710	3,278	3,405	3,388	3,227	3,387	3,003	2,807	2,399	2,994	3,321	3,565	3,825	2,671	3,163	-491
3140106	**33**	n.a.	3,713	4,669	6,342	6,518	5,803	5,756	3,939	3,782	4,104	3,487	3,239	3,967	4,033	10,573	5,467	4,641	826
3140305	**33**	n.a.	3,713	4,669	6,342	6,518	5,803	5,756	3,939	3,782	4,104	3,487	3,239	3,967	4,033	10,573	5,467	4,641	826

Table F-3 Comparison Between Sediment Change and Construction Change for Each Watershed

Watersheds (HUCs)	Average Annual Sediment (Tonnes/Inch of Rain)			Average Annual Number of Construction Permits From Corresponding Counties			Change in Tandem
	1980–1986	1987–1994	% Change	1980–1986	1987–1994	% Change	
3080101	313	491	36%	67,063	65,384	-3%	-
3080201	24	4	-483%	18961	19,043	0%	+
3090101	77	100	23%	43495	45,577	5%	-
3090103	14	20	27%	3287	3,055	-8%	-
3090205	254	113	-124%	19270	18,317	-5%	+
3100101	1,871	187	-901%	32004	27,465	-17%	+
3100204	257	73	-253%	28717	24,409	-18%	+
3110206	52	83	37%	4027	3,669	-10%	-
3140103	534	519	-3%	2671	3,163	16%	+
3140106	210	243	13%	5467	4,641	-18%	-
3140305	4,609	4,449	-4%	5,467	4,641	-18%	-
Total	8215	6282	-31%	230429	219364	-5%	+

The totals from Table F-3 suggest that for each comparison it may be useful to look at the magnitude of the change in sediment loads and not just the direction of the change. For example, when sediment rates fell or rose in relation to the construction rates was the magnitude greater than it was for those instances when they did not change in tandem? The Wilcoxon signed-rank test was used to compare the rates of sediment load increase or decrease and ranked to determine if the magnitude of the change was significant.[5] Table F-4 shows the percentage increase or decrease between the first and second period for both sediment loadings and construction and the results of the Wilcoxon signed-rank test. The positive result of the summed rankings provides additional evidence suggesting that sediment and erosion controls have had a positive impact on water quality protection when the magnitude of the rainfall and corresponding sediment loads are considered.

In conclusion, the results suggest that the sediment load is reduced by the implementation of construction erosion and sediment controls. Although this analysis was performed on selected watersheds within the state of Florida, EPA believes the results to be applicable to other high growth watersheds in the United States.

Table F-4 Wicoxon Signed-Rank Test for Comparison of Changes

Watersheds (HUCs)	Sediment % Change	Construction % Change	Difference in Change	Absolute Value of Difference	Rank of Difference	Change in Tandem	Signed Rank
3080101	36%	-3%	34%	34%	7	-	-7
3080201	-483%	0%	-482%	482%	10	+	10
3090101	23%	5%	18%	18%	4	-	-4
3090103	27%	-8%	19%	19%	5	-	-5
3090205	-124%	-5%	-119%	119%	8	+	8
3100101	-901%	-17%	-884%	884%	11	+	11
3100204	-253%	-18%	-235%	235%	9	+	9
3110206	37%	-10%	27%	27%	6	-	-6
3140103	-3%	16%	13%	13%	2	+	2
3140106	13%	-18%	-4%	4%	1	-	-1
3140305	-4%	-18%	14%	14%	3	-	-3

[5] Newmark, Joseph.1992. *Statistics and Probability in Modern Life*. 5th edition. Saunders College Publishing, New York, NY.